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A comparison between maximum length sequence and conventional auditory brainstem responses as a screening tool for auditory sensitivity

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A Comparison Between Maximum Length Sequence and Conventional Auditory Brainstem Responses as a Screening Tool for Auditory Sensitivity

Independent Study Project
Central Institute for the Deaf
St. Louis, MO
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Abstract

Auditory brainstem response testing is a well established physiologic measurement technique. Maximum Length Sequence ABRs were developed to overcome some of the limitations of conventional ABRs. The purpose of this study was to compare conventional and MLS ABRs. Results indicated that MLS could yield comparable binaural waveforms in approximately the same amount of time as a monaural conventional ABR. Further, it was found that the stimulus dependencies of Wave V are similar for both types of test, and that MLS could be used to determine the threshold of sensitivity. Thus, MLSs could prove to be an efficient and accurate screening tool for auditory sensitivity.

The measurement of auditory brainstem responses (ABR) is a well established tool for objective, physiologic audiometry. This widespread acceptance of ABRs continues to motivate efforts to bring improvements in efficiency and accuracy to evoked potential methodology (Burkard, Shi, and Hecox, 1990b). The development of Maximum Length Sequence (MLS) ABRs by Eysholdt and Schreiner in 1982 was one such effort at improvement. MLS is reported to enable faster stimulation rates, a higher signal to noise ratio, and faster measurement of the auditory brainstem response while obtaining accurate results comparable to conventional ABR measures (Chan, Lam, Poon, and Du, 1992).

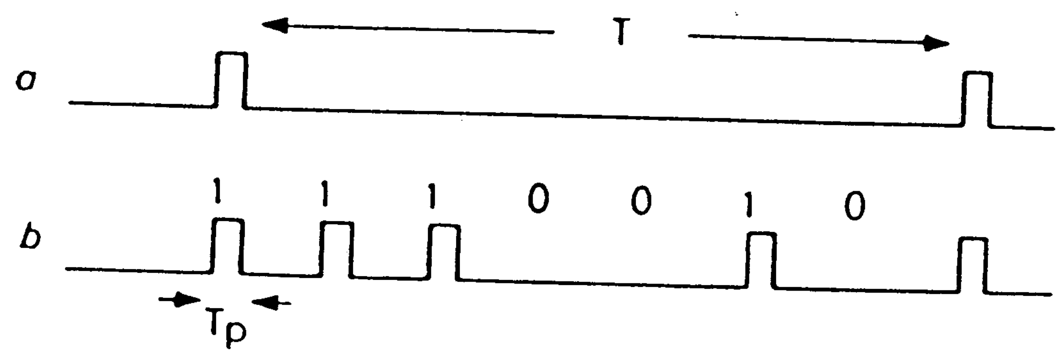
The stimulation and recording techniques of conventional ABRs require that the brainwave response to one stimulus be completed prior to delivery of the next stimulus. In ABRs, response components have a 10-12 ms duration following stimulus onset. The duration of the click stimulus is 100 us. Therefore, a maximum rate of 80-100 clicks/s is imposed to avoid overlapping responses. Once a response has overlapped with a previous one, it is impossible to extract the original waveform using conventional averaging techniques (Thornton and Slaven, 1993).

Maximum Length Sequence ABRs attempt to overcome the limitations of conventional ABRs. MLS testing utilizes a stimulus that consists of distinct pulses of uniform polarity and amplitude occurring at pseudorandom time intervals. Due to the nature of the stimulus and the newly developed processing techniques, it is not necessary to wait for the response to each pulse to be completed before the next pulse is delivered. Thus, pulses may be delivered at maximum rates of up to 1000 clicks/s. As in conventional ABRs, each waveform is filtered, and the waveforms are averaged. The final response is then obtained by mathematically cross-correlating the collected data with a recovery sequence which is supplied by the MLS software (Nicolet, 1991). This process is termed deconvolving.

Figure 1 depicts the stimuli patterns for both types of ABRs. T represents the period of the stimuli sequence. T_p

is the duration of the click. In conventional ABRs (a) T is the time between click presentations. During T, the response to the stimulus is completed, before the onset of the next click. In MLS (b), there are several clicks presented in pulse trains during T, because it is not necessary for the brainstem response to one click to be completed prior to the onset of the next.

Figure 1



An extremely poor signal to noise ratio (SNR) from the response to a single stimulus is a measurement difficulty in conventional ABR testing. Early wave components with an amplitude of 0.1-0.5 uV are embedded in a very noisy background of continuous electrical activity corresponding to the ongoing EEG and muscle activity that have amplitudes of approximately 50 uV. The low SNR of ABRs has led to the use of averaging as a signal-enhancement process (Chan et al., 1992). Signal averaging of two thousand trials is usually necessary to extract the ABR from the background EEG activity.

In MLS testing, random binary sequences are used as stimuli to improve the SNR of the evoked response. The EEG signal and electrical interference behave as noise added to the convoluted signal. The resultant signal is then deconvolved. Although the signal contained more power prior to deconvolution, after this process, the signal will be decreased to the same as that obtained from a single click stimulus. The noise is also diminished by the deconvolution process, maintaining a high SNR (Chan et al., 1992).

The MLS technique allows for the collection of data from both ears simultaneously with no significant binaural interaction effects. Right and left ears are assessed nearly simultaneously without loss of information from the separate ears because the two ears respond independently. The MLS test is termed an "asynchronous binaural" test because the stimulus used is a pseudorandom series of pulses that are arranged so as not to appear simultaneously in both ears. For an MLS asynchronous binaural test, the stimuli are applied to both ears with one stimuli circularly delayed relative to the other. This delay, coupled with the fact that the stimulus itself is a series of pulses, enables data collection through only one channel, and for the responses from both ears to be extracted, through cross-correlation, from the data collected (Nicolet, 1991). Conventional ABRs are typically collected monaurally because conventional binaural ABRs require two channels, each channel displaying the ipsilateral response from one ear combined with the contralateral response from the other ear.

The purpose of this study was to investigate the effectiveness of binaural MLS ABRs as compared to conventional ABR testing as a screening tool of auditory sensitivity. If found to be an efficient and accurate screening tool, MLS could have useful applications for clinical audiology.

Method

Subjects

The subjects for this study were ten adults, 22-48 years of age. Nine subjects had normal hearing sensitivity bilaterally, and one subject had normal hearing in the right ear only. Normal hearing sensitivity was defined as thresholds less than or equal to 20 dB HL at octave frequencies from 250 Hz to 8000 Hz, inclusive. (See appendix.) Data collected from 19 ears was used for analysis. Recruitment of subjects was on a volunteer basis.

Stimuli

A Nicolet Spirit was used to generate the stimuli for both conventional and MLS ABRs. When possible, stimulus parameters were kept constant for both types of ABR. The transducers for both tests were TDH-39 earphones.

The stimulus for the conventional ABR was rarefaction clicks with a duration of 100 us. The rate of stimulation was 21.1 clicks per second. Intensity levels employed were 60, 30, 20, 10, 5, and 0 dB nHL.

The stimulus for MLS ABR was a pseudorandom binary pulse train of rarefaction clicks. It was a binary sequence in that there were only two units, +1s and -1s. In practice, binary applications may be represented by +1s and 0s or by clicks and silences (Thornton and Slaven, 1993). The MLS was a sequence of pulses whose interpulse intervals (IPI) vary pseudorandomly; half of the pulses were separated by the minimum IPI, the remaining pulses were separated by integer multiples of the minimum IPI (Lasky, Shi, and Hecox, 1993). The Nicolet Spirit selects the order of the MLS once the time window and stimulus rate are chosen. For this study, as depicted in Table 1, the rates and orders were as follows: 200 clicks/s (order 5), 400 clicks/s (order 6), 800 clicks/s (order 7) (Thornton and Slaven, 1993). Time shifted versions of the same sequence were presented simultaneously to each ear (Lasky et al., 1993).

Table 1

RATE (CLICKS/S)	ORDER
200	5
400	6
800	7

Responses

Response parameters were held constant between the two types of ABR, whenever possible. The low and high frequency filters were set at 150 Hz and 3000 Hz, respectively. Sensitivity was 20 uV and artifact rejection was employed for both tests. An artifact is any unwanted signal of physiologic or electrical origin. In this context, it is any received signal after amplification that exceeds 90 percent of the analog/digital voltage range. A circuit in the evoked potential instrument rejects those signals exceeding that set voltage. This limits the contamination of collected waveforms by artifacts (Nicolet, 1991). A 10 ms time window was required for conventional ABR while MLS required a 24 ms time window, with a 0 ms delay for each.

Procedure

Normal hearing sensitivity, as defined above, was verified through pure tone air conduction audiometry. Testing was performed with a Grason-Stadler GSI 16 audiometer.

Subjects were prepared for electrode placement by cleansing the skin with alcohol and Omniprep. Four disposable silver/silver chloride electrodes were applied. Electrode sites were used as follows: F_z (noninverting), A_1 and A_2 (inverting), and F_{pz} (common ground). A jumper cable linking A_1 and A_2 was necessary for MLS testing. Electrode impedance was less than 5 kohms, and the impedance difference between any two electrodes was less than 2 kohms.

Conventional ABR testing was conducted next. Data was collected for both ears, monaurally. The rate used was 21.1 clicks/s. An intensity series was collected. Intensity levels used were 60, 30, 20, 10, 5, and 0 dB nHL. The series was stopped after the disappearance of Jewett Wave V. Two thousand sweeps were collected at each level.

MLS testing was conducted last. Data was collected binaurally because of the asynchronous simultaneous stimulation of both ears. Three rates were tested: 200, 400, and 800 clicks/s. At each rate, an intensity series was collected. Levels used were 60, 30, 20, 10, 5, and 0 dB nHL or until the disappearance of Jewett Wave V. Eight hundred sweeps were collected at each level.

Results

Tables 2-5 display a breakdown of the Jewett Wave V absolute latency means and standard deviations for this study. absolute latency was a measure of the waveform latency from the time of onset to the peak of the wave. For all click rates, there was an increase in Wave V latency as the click intensity decreased. The latency shift for conventional ABR was on the order of 0.3-0.8 ms which was slightly broader than the normed range of 0.4-0.6 ms (Parthasarathy, 1994). The latency shift ranges for MLS rates 200, 400, and 800 clicks/s were 0.4-0.9, 0.6-0.9, and 0.1-0.9 ms respectively. Norms for MLS data were not available. Figure 2 depicts the latency-intensity function for each rate of stimulation.

The mean absolute latencies for Wave V for conventional ABR were within normal limits (Hall, 1992). Normative data was not available for MLS ABR latencies. Wave V interaural latency differences for all waves were within ±0.3 ms with the exception of the 0.6 ms interaural difference at 5 dB nHL in conventional ABR.

Tables 5-9 display a breakdown of the of the Jewett Wave V absolute amplitude means and standard deviations for this study. Absolute amplitude was the size of the evoked potential waveform from the peak of a wave to the following trough. ABR amplitudes are highly variable and susceptible to the effects of movement artifact and background EEG activity (Hall, 1992). There was a decrease in Wave V amplitude as click intensity decreased for all stimulus rates. Figure 3 depicts the amplitude-intensity function for each rate of stimulation. Interaural amplitude differences were within ±0.03 uV with the exception of 0.12 uV at 5 dB nHL in conventional ABR.

Several subjects reported that the MLS stimuli was annoying, especially at 60 dB nHL. This may account for high artifact rejection rates for those waveforms.

Data collection for binaural MLS ABRs was faster than for conventional ABRs by approximately a factor of two. In other words, binaural MLS yielded comparable results for two ears in the same amount of time conventional ABRs yielded monaural results.

Discussion

As conventional ABRs to click stimuli are thought to represent the impulse response of the auditory pathway; the deconvolved MLS response should be virtually identical to the conventional ABR (Burkard, Shi, and Hecox, 1990a). The results of this study show a brainstem response recorded using MLS analysis was similar to that recorded using conventional recording techniques.

Emphasis in this study was placed on Jewett Wave V because of its large amplitude, stability, and occurrence, at or near the threshold of hearing (Don, Allen, and Starr, 1977). Findings in this study were consistent with the literature. With decreasing click intensity, there was an increase in Wave V latency and a decrease in Wave V amplitude. There was also an increase in latency and decrease in amplitude found with increasing stimulus rate (Burkard et al., 1990; Eysholdt & Schreiner, 1982; Don et al., 1977). The stimulus dependencies for Wave V are similar for both conventional and MLS ABR. This similarity in stimulus dependencies supports the position that the deconvolution process yields responses which are very similar to conventional ABRs.

The observation of increasing latency and decreasing amplitude with decreasing stimulus levels has motivated the study of the contribution of auditory brainstem responses to the clinical evaluation of auditory function as well as diagnosis of certain neurological impairments. In addition, MLSs, with maximum rates up to 1000 Hz, allow for the study of adaptive processes in humans, at rates approaching the absolute refractory periods of auditory neurons. These refractory studies could enhance the sensitivity of the ABR to compromised neural function as in multiple sclerosis (Burkard et al., 1990b).

Debruyne (1986) studied ABR latency shifts as a function of increasing stimulus repetition rate. There appears to be an accumulative retardation of the successive waves when faster clicks are presented. Effects on Wave V seem to intensify with age, especially over 55 years. That was the reason for the age limitations for subjects in this study. However, a tendency was noted that higher gain was needed to identify waveform components for older subjects than younger ones.

One advantage of MLS evoked potentials is the faster stimulus rate. Lasky et al. (1993) list two reasons; to examine rate effects and to reduce data collection time. However, the increased stimulus rates associated with MLS evoke smaller amplitude responses, thus a greater number of pulses must be presented in order to achieve the same SNR as conventional ABRs at slower rates. "Any assessment of the value of MLS ABRs in reducing test time must take into account the higher noise levels inherent in this procedure" (Marsh, 1992). Further, artifact rejection and additional computations potentially can slow MLS recordings more than conventional recordings (Lasky et al., 1993). Nonetheless, the ability of recording MLSs binaurally reduces by half the data collection time of monaural ABRs.

ABRs can be recorded at very rapid stimulus rates. The response is not as clearly defined as when recorded at slower rates using conventional averaging: Wave V is broader, later in latency, lower in amplitude; earlier waves are difficult to recognize. Still, the MLS technique will be very helpful in situations where speed is important and the presence of Wave V is informative, such as inoperative monitoring, pediatric audiology, and auditory and neural screenings. It may also be useful in detecting abnormalities of auditory processing that are only evident at rapid stimulation rates (Picton et al., 1992).

The purpose of this study was to assess the efficiency and accuracy of MLS as a screening tool for auditory sensitivity. Results indicate that the evaluation of hearing thresholds seems to be as good with the fast MLS technique (Eysholdt & Schreiner, 1982). Further, the use of pseudorandom pulse trains and deconvolution allows for ABR collection at faster stimulation rates and could potentially reduce data collection time per waveform and per patient (Burkard et al., 1990b). This could maximize efficiency while maintaining accuracy.

Acknowledgements

The author gratefully acknowledges Brad Pugh for his guidance in this project and the use of test equipment. Thanks also to everyone at Midwest Otologic Group for their cooperation. The author greatly appreciates the supervision and helpful comments of Dr. Gerald Popelka. A special thank you to all the subjects who volunteered for this study.

Table 2

CONVENTIONAL ABR 21.1 CLICKS/S
WAVE V LATENCY (ms)

INTENSITY (dB nHL)	EAR	NUMBER	MEAN	STANDARD DEVIATION
60	L	9	6.04	0.60
60	R	10	5.93	0.65
30	L	9	7.44	0.76
30	R	10	7.37	0.66
20	L	9	8.01	0.90
20	R	8	8.17	0.79
10	L	7	8.39	0.69
10	R	9	8.47	0.62
5	L	2	8.25	0.75
5	R	1	8.80	----

Table 3

MLS ABR 200 CLICKS/S
WAVE V LATENCY (ms)

INTENSITY (dB nHL)	EAR	NUMBER	MEAN	STANDARD DEVIATION
60	L	9	6.83	0.25
60	R	10	6.93	0.39
30	L	9	8.02	0.46
30	R	10	8.13	0.46
20	L	8	8.79	0.66
20	R	9	8.77	0.59
10	L	6	9.68	0.66
10	R	3	9.71	0.97

Table 4

MLS ABR 400 CLICKS/S
WAVE V LATENCY (ms)

INTENSITY (dB nHL)	EAR	NUMBER	MEAN	STANDARD DEVIATION
60	L	9	7.60	0.64
60	R	10	7.51	0.54
30	L	9	8.44	0.57
30	R	10	8.42	0.61
20	L	9	9.04	0.60
20	R	10	9.21	0.71
10	L	5	9.83	0.77
10	R	7	10.15	0.73

Table 5

MLS ABR 800 CLICKS/S
WAVE V LATENCY (ms)

INTENSITY (dB nHL)	EAR	NUMBER	MEAN	STANDARD DEVIATION
60	L	9	7.65	0.65
60	R	10	7.60	0.69
30	L	9	8.50	0.60
30	R	10	8.45	0.71
20	L	8	9.11	0.67
20	R	7	9.06	0.85
10	L	3	9.21	0.47
10	R	3	9.20	0.64

Table 6

CONVENTIONAL ABR 21.1 CLICKS/S
WAVE V AMPLITUDE (uV)

INTENSITY (dB nHL)	EAR	NUMBER	MEAN	STANDARD DEVIATION
60	L	9	0.27	0.06
60	R	10	0.24	0.06
30	L	9	0.19	0.07
30	R	10	0.19	0.10
20	L	9	0.12	0.04
20	R	8	0.14	0.06
10	L	7	0.07	0.06
10	R	9	0.06	0.03
5	L	2	0.13	0.00
5	R	1	0.25	----

Table 7

MLS ABR 200 CLICKS/S
WAVE V AMPLITUDE (uV)

INTENSITY (dB nHL)	EAR	NUMBER	MEAN	STANDARD DEVIATION
60	L	9	0.16	0.05
60	R	10	0.15	0.06
30	L	9	0.13	0.05
30	R	10	0.11	0.07
20	L	8	0.07	0.02
20	R	9	0.06	0.02
10	L	6	0.06	0.02
10	R	3	0.04	0.01

Table 8

MLS ABR 400 CLICKS/S
WAVE V AMPLITUDE (uV)

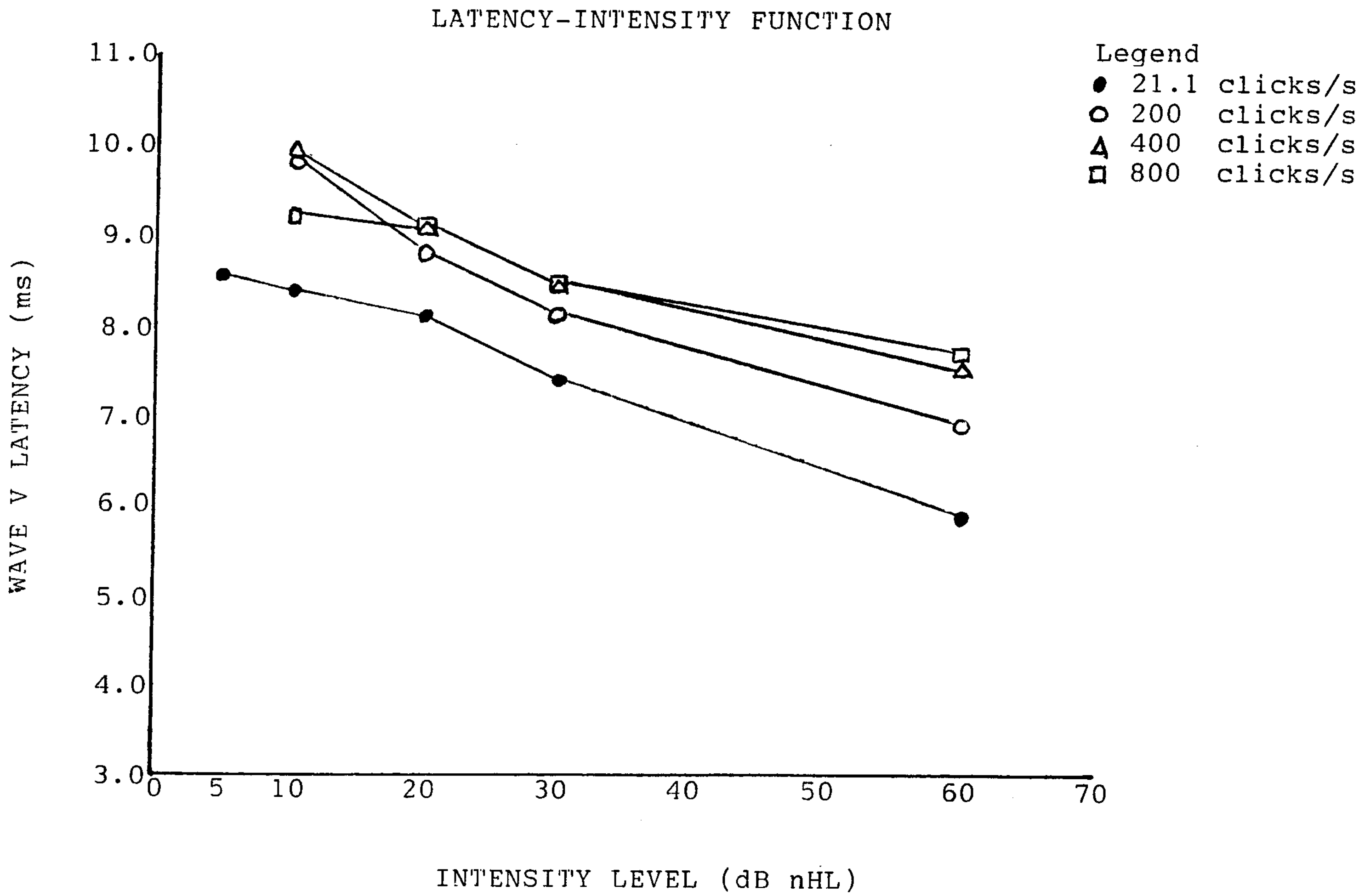
INTENSITY (dB nHL)	EAR	NUMBER	MEAN	STANDARD DEVIATION
60	L	9	0.11	0.04
60	R	10	0.12	0.03
30	L	9	0.08	0.02
30	R	10	0.06	0.02
20	L	8	0.05	0.02
20	R	10	0.04	0.01
10	L	5	0.04	0.02
10	R	7	0.03	0.01

Table 9

MLS ABR 800 CLICKS/S
WAVE V AMPLITUDE (uV)

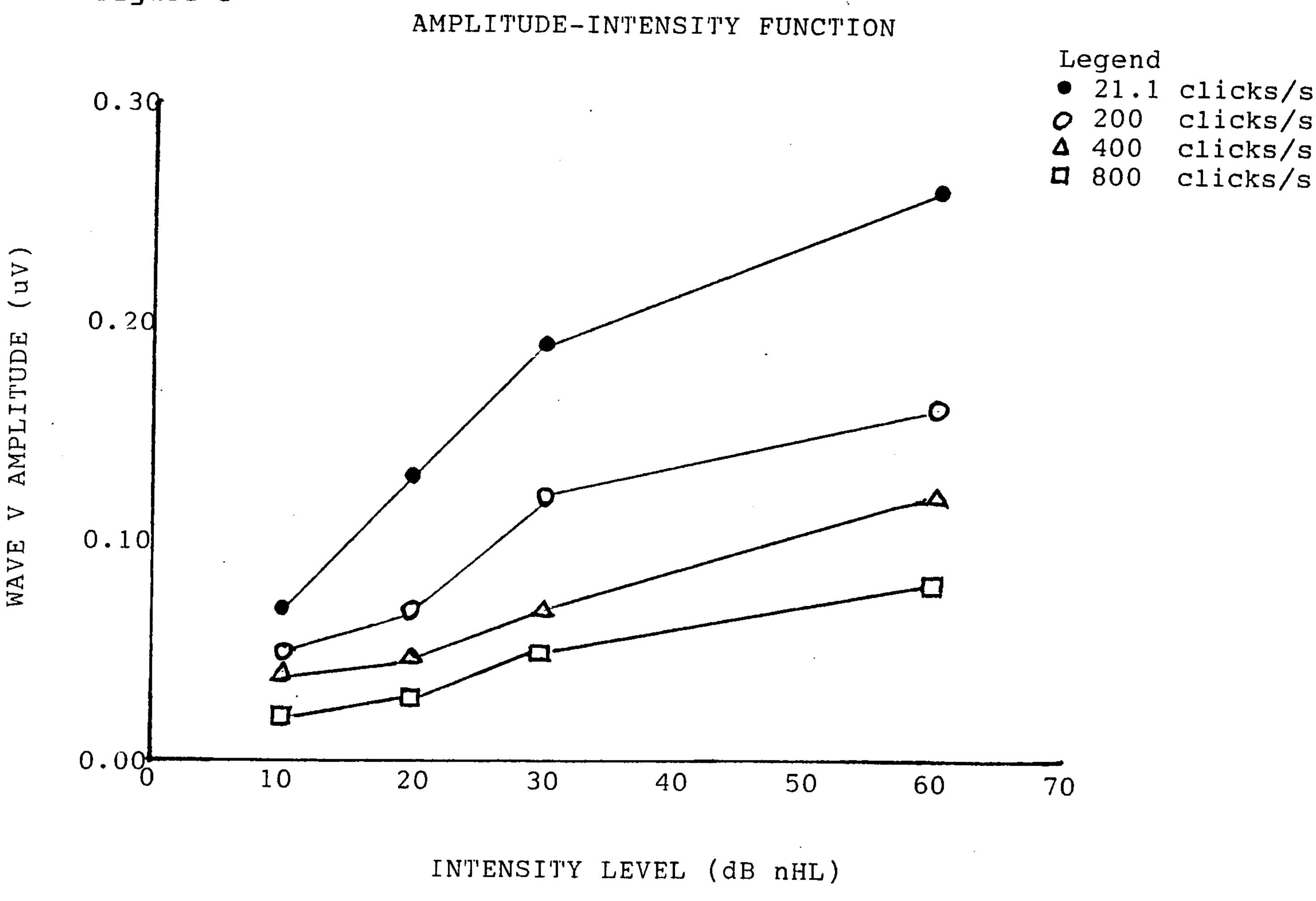
INTENSITY (dB nHL)	EAR	NUMBER	MEAN	STANDARD DEVIATION
60	L	9	0.07	0.02
60	R	10	0.08	0.04
30	L	8	0.05	0.02
30	R	10	0.05	0.03
20	L	7	0.03	0.01
20	R	7	0.03	0.01
10	L	2	0.02	0.00
10	R	1	0.01	----

Figure 2



LATENCY-INTENSITY FUNCTION
Legend
21.1 clicks/s
200 clicks/s
400 clicks/s
800 clicks/s
WAVE V LATENCY (ms)
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
0
5
10
20
30
40
50
60
70
INTENSITY LEVEL (dB nHL)

Figure 3


AMPLITUDE-INTENSITY FUNCTION
Legend
21.1 clicks/s
200 clicks/s
400 clicks/s
800 clicks/s
0.30
0.20
0.10
0.00
WAVE V AMPLITUDE (uV)
0
10
20
30
40
50
60
70
INTENSITY LEVEL (dB nHL)

Appendix

SUBJECT 01

UDIOMETER	DATE		RIGHT EAR 125	250	500	1000	2000	3000	4000	6000	8000	LEFT EAR 125	250	500	1000	2000	3000	4000	6000	8000	TESTER
GSI 16	3/16/ 95	AC		10	15	5	0		5		15		5	10	5	0		5		15	SKW
		BC																			

OMMENTS:

SUBJECT 02

UDIOMETER	DATE		RIGHT EAR 125	250	500	1000	2000	3000	4000	6000	8000	LEFT EAR 125	250	500	1000	2000	3000	4000	6000	8000	TESTER
GSI 16	3/23/ 95	AC		5	15	10	0		15		5		10	10	15	0		10		0	SKW
		BC																			

OMMENTS:

SUBJECT 03

AUDIOMETER	DATE		RIGHT EAR 125	250	500	1000	2000	3000	4000	6000	8000	LEFT EAR 125	250	500	1000	2000	3000	4000	6000	8000	TESTER
GSI 16	3/23/ 95	AC		10	20	10	0		5		15		5	5	10	5		10		20	SKW
		BC																			

COMMENTS:

SUBJECT 04

AUDIOMETER	DATE		RIGHT EAR 125	250	500	1000	2000	3000	4000	6000	8000	LEFT EAR 125	250	500	1000	2000	3000	4000	6000	8000	TESTER
GSI 16	3/30/ 95	AC		10	10	15	10		10		10		5	10	5	5		0		10	SKW
		BC																			

COMMENTS:

SUBJECT 05

UDIOMETER	DATE		RIGHT EAR 125	250	500	1000	2000	3000	4000	6000	8000	LEFT EAR 125	250	500	1000	2000	3000	4000	6000	8000	TESTER
GSI 16	3/30/ 95	AC		5	5	0	-5		0		10		5	0	10	10		15		10	SKW
		BC																			

OMMENTS:

SUBJECT 06

UDIOMETER	DATE		RIGHT EAR 125	250	500	1000	2000	3000	4000	6000	8000	LEFT EAR 125	250	500	1000	2000	3000	4000	6000	8000	TESTER
GSI 16	3/30/ 95	AC		10	15	10	5		10		15		30	25	25	35		35		35	SKW
		BC																			

OMMENTS:

SUBJECT 07

UDIOMETER	DATE		RIGHT EAR 125	250	500	1000	2000	3000	4000	6000	8000	LEFT EAR 125	250	500	1000	2000	3000	4000	6000	8000	TESTER
SI 16	4/06/ 95	AC		0	10	5	-5		-5		0		5	10	0	10		0		5	SKW
		BC																			

OMMENTS:

SUBJECT 08

AUDIOMETER	DATE		RIGHT EAR 125	250	500	1000	2000	3000	4000	6000	8000	LEFT EAR 125	250	500	1000	2000	3000	4000	6000	8000	TESTER
SI 16	4/06/ 95	AC		5	10	5	0		0		20		5	10	10	0		0		20	SKW
		BC																			

COMMENTS:

SUBJECT 09

			RIGHT EAR									LEFT EAR									
UDIOMETER	DATE		125	250	500	1000	2000	3000	4000	6000	8000	125	250	500	1000	2000	3000	4000	6000	8000	TESTER
GSI 16	4/06/ 95	AC		10	5	5	-5		10		5		15	5	0	-10		5		20	SKW
		BC																			

OMMENTS:

SUBJECT 10

			RIGHT EAR									LEFT EAR									
UDIOMETER	DATE		125	250	500	1000	2000	3000	4000	6000	8000	125	250	500	1000	2000	3000	4000	6000	8000	TESTER
GSI 16	4/18/ 95	AC		0	5	10	5		0		5		5	0	5	0		-10		20	SKW
		BC																			

OMMENTS:

			RIGHT EAR									LEFT EAR									
AUDIOMETER	DATE		125	250	500	1000	2000	3000	4000	6000	8000	125	250	500	1000	2000	3000	4000	6000	8000	TESTER
		AC																			
		BC																			

COMMENTS:

			RIGHT EAR									LEFT EAR									
AUDIOMETER	DATE		125	250	500	1000	2000	3000	4000	6000	8000	125	250	500	1000	2000	3000	4000	6000	8000	TESTER
		AC																			
		BC																			

COMMENTS:

			RIGHT EAR									LEFT EAR									
UDIOMETER	DATE		125	250	500	1000	2000	3000	4000	6000	8000	125	250	500	1000	2000	3000	4000	6000	8000	TESTER
		AC																			
		BC																			

OMMENTS:

			RIGHT EAR									LEFT EAR									
UDIOMETER	DATE		125	250	500	1000	2000	3000	4000	6000	8000	125	250	500	1000	2000	3000	4000	6000	8000	TESTER
		AC																			
		BC																			

OMMENTS:

			RIGHT EAR									LEFT EAR									
JDIOMETER	DATE		125	250	500	1000	2000	3000	4000	6000	8000	125	250	500	1000	2000	3000	4000	6000	8000	TESTER
		AC																			
		BC																			

OMMENTS:

			RIGHT EAR									LEFT EAR									
AUDIOMETER	DATE		125	250	500	1000	2000	3000	4000	6000	8000	125	250	500	1000	2000	3000	4000	6000	8000	TESTER
		AC																			
		BC																			

COMMENTS:

CENTRAL INSTITUTE FOR THE DEAF
AT WASHINGTON UNIVERSITY MEDICAL CENTER

Founded 1914

CONSENT FOR PARTICIPATION IN RESEARCH

I hereby agree to participate in the research project entitled "A comparison of binaural MLS ABRs to conventional ABRs as a screening tool for auditory sensitivity to be conducted at the Central Institute for the Deaf.** I have read the accompanying descriptions of this project and understand that I am free to discontinue participation at any time without prejudice. I also understand that any questions I might have concerning this research will be answered by the supervisors. My consent to participate does not in any way release Central Institute for the Deaf from its responsibility for my welfare during the hours of my participation whether as a paid subject or in any other capacity.

Date__________________ Signed* __________________

Print name__________________

Address__________________

____

*To be signed by parent or legal guardian if the participant is under eighteen years of age.

Category of subject participation (subject initials one):

_____ a) Volunteer
_____ b) Part of a more general job description with supervisor's approval
_____ c) Part-time employee as paid subject
_____ d) Credit in work study program

**Testing for this study will be conducted at Midwest Otologic Group, at St. John's Mercy Hospital Doctor's Building.

Approved by CID's Institutional Review Board 6/23/93

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What is an ABR?

An ABR (auditory brainstem response) is a test which measures the function and/or sensitivity of the peripheral auditory pathway. Electrodes are placed in four areas on the head. These electrodes record electrical activity at the level of the brainstem. This electrical activity is in response to a click stimuli that the subject hears through earphones. The electrodes in no way stimulate the subject. An ABR is similar to an EEG or EKG, in this respect. Active participation is not required of the subject. He or she will be instructed to relax or sleep during testing. Sedation is not required for adult subjects.

Electrode Placement

Four small areas on the head will need to be prepared for electrode placement. First, the skin is cleansed with an alcohol wipe. Next, the skin is rubbed with Omni-Prep, which is similar to a facial scrub. This serves to remove oil and dead skin cells from the surface, so that the electrodes will be able to record accurately. Then, electrodes are placed on the clean areas, and held in place with an adhesive.

Note: Skin may be slightly dry or irritated in the four small areas due to the use of alcohol and facial scrub.

My supervisors or I will be happy to answer any questions regarding ABRs and the research that is being conducted. Thank you for your participation in this investigation.

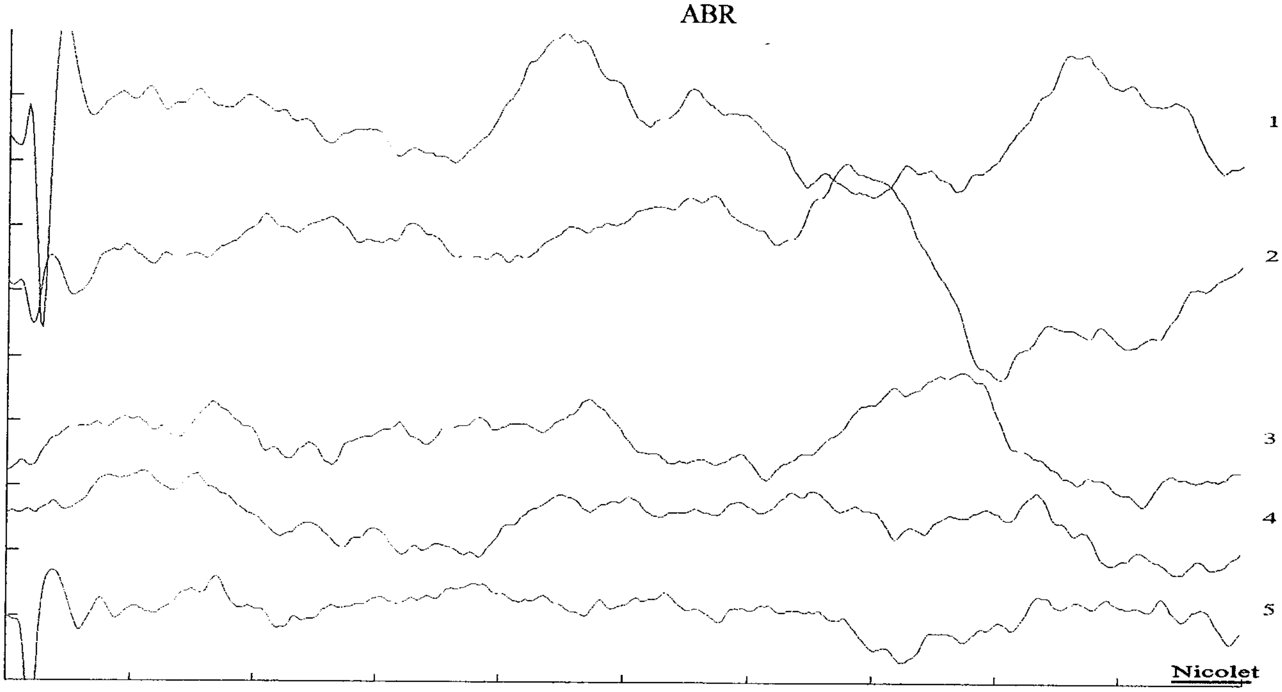
Midwest Otologic Group
621 South New Ballas Road, Tower C-597
St. Louis, Missouri 63141
(314) 432-5151, fax 432-8795

Last:
First:
Med ID: 09
Birthdate: 11/10/72
Gender: f
Date: 04/06/95
Examiner: skw

Case History:

Notes/Impressions:

ABR



Sensitivity and Sweep Time Per Division

1	0.12 uV	1.0 msec	2	0.12 uV	1.0 msec	3	0.12 uV	1.0 msec	4	0.12 uV	1.0 msec	5	0.12 uV	1.0 msec

Midwest Otologic Group
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St. Louis, Missouri 63141
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ABR

AMP	Elect	Mode	Sns	Lff	Hff	Notch	Artifact	REM	Remarks
1	Fz-A2	Run	20uV	150Hz	3K	Off	On	1	
2	Fz-A2	Run	20uV	150Hz	3K	Off	On	2	
3	Fz-A2	Run	20uV	150Hz	3K	Off	On	3	
4	Fz-A2	Run	20uV	150Hz	3K	Off	On	4	
5	Fz-A2	Run	20uV	150Hz	3K	Off	On	5	

ACQ	Comm	Sweep	Time	Delay	Rate	Trigger	Stim	MISC	Type	Ch#	Accept	Reject	Filter	Fsp/SNR	Date	Time	Add	Sub	Inv	Filter	Smooth
1	A	2000	10ms	0ms	21.1	Inter	Gated	1	Sum	2	2000	305	Butter	-31.00dB	04/06/95	13:43	no	no	no	no	no
2	A	2000	10ms	0ms	21.1	Inter	Gated	2	Sum	2	2000	38	Butter	-29.96dB	04/06/95	13:45	no	no	no	no	no
3	A	2000	10ms	0ms	21.1	Inter	Gated	3	Sum	2	2000	4	Butter	-31.73dB	04/06/95	13:47	no	no	no	no	no
4	A	2000	10ms	0ms	21.1	Inter	Gated	4	Sum	2	2000	1	Butter	-32.14dB	04/06/95	13:49	no	no	no	no	no
5	A	2000	10ms	0ms	21.1	Inter	Gated	5	Sum	2	2000	0	Butter	-32.85dB	04/06/95	13:51	no	no	no	no	no

STIM	Trans	Type	Pol	Dur	Level	Freq	Pla	Ramp	Env	Noi	NLev	dB	Trans	Type	Pol	Dur	Level	Freq	Pla	Ramp	Env	Noi	NLev	dB
1	Phone	Off								Off		nHL	Phone	Click	Rar	100us	60					Off		nHL
2	Phone	Off								Off		nHL	Phone	Click	Rar	100us	30					Off		nHL
3	Phone	Off								Off		nHL	Phone	Click	Rar	100us	20					Off		nHL
4	Phone	Off								Off		nHL	Phone	Click	Rar	100us	10					Off		nHL
5	Phone	Off								Off		nHL	Phone	Click	Rar	100us	5					Off		nHL

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Last:
Med ID: 09
Date: 04/06/95

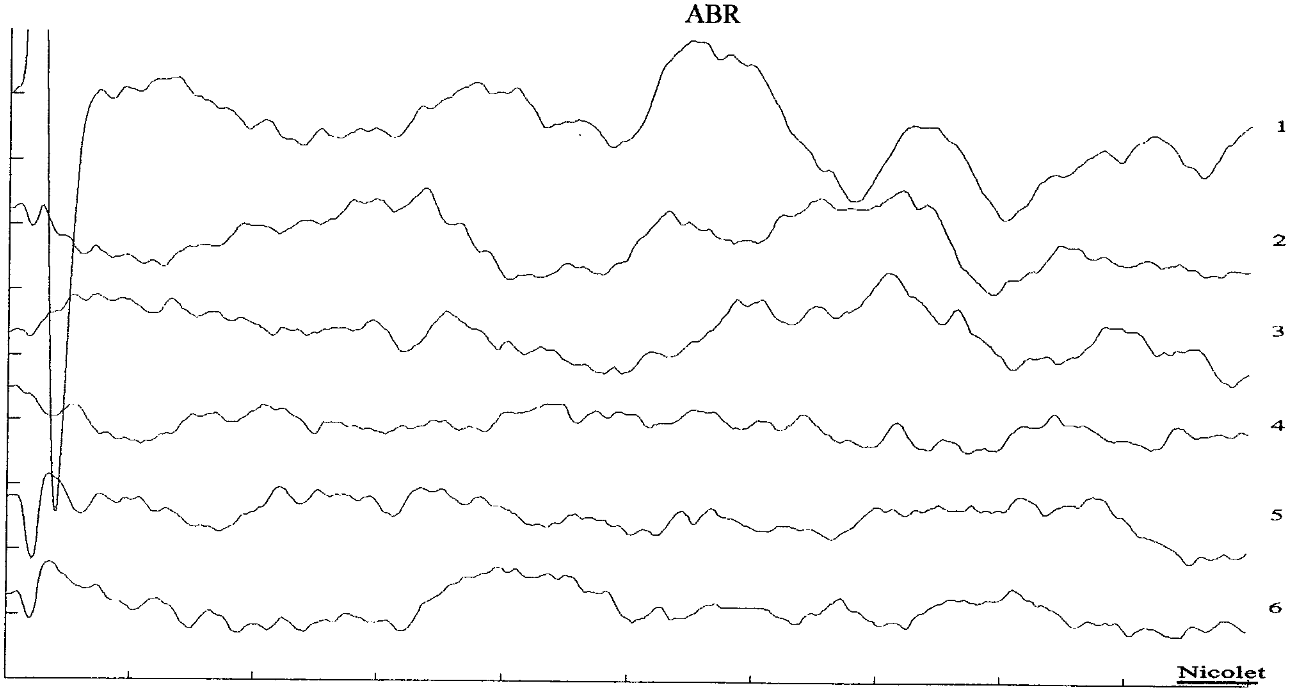
First:
Birthdate: 11/10/72
Examiner: skw

Gender: f

Case History:

Notes/Impressions:

ABR



Sensitivity and Sweep Time Per Division

1	0.12 uV	1.0 msec	2	0.12 uV	1.0 msec	3	0.12 uV	1.0 msec	4	0.12 uV	1.0 msec	5	0.12 uV	1.0 msec	6	0.12 uV	1.0 msec

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ABR

AMP	Elect	Mode	Sns	Lff	Hff	Notch	Artifact	REM	Remarks
1	Fz-A1	Run	20uV	150Hz	3K	Off	On	1	
2	Fz-A1	Run	20uV	150Hz	3K	Off	On	2	
3	Fz-A1	Run	20uV	150Hz	3K	Off	On	3	
4	Fz-A1	Run	20uV	150Hz	3K	Off	On	4	
5	Fz-A1	Run	20uV	150Hz	3K	Off	On	5	
6	Fz-A1	Run	20uV	150Hz	3K	Off	On	6	

ACQ	Comm	Sweep	Time	Delay	Rate	Trigger	Stim	MISC	Type	Ch#	Accept	Reject	Filter	Fsp/SNR	Date	Time	Add	Sub	Inv	Filter	Smooth
1	A	2000	10ms	0ms	21.1	Inter	Gated	1	Sum	1	2000	24	Butter	-28.16dB	04/06/95	13:31	no	no	no	no	no
2	A	2000	10ms	0ms	21.1	Inter	Gated	2	Sum	1	2000	8	Butter	-30.38dB	04/06/95	13:33	no	no	no	no	no
3	A	2000	10ms	0ms	21.1	Inter	Gated	3	Sum	1	2000	0	Butter	-31.73dB	04/06/95	13:35	no	no	no	no	no
4	A	2000	10ms	0ms	21.1	Inter	Gated	4	Sum	1	2000	0	Butter	-36.12dB	04/06/95	13:36	no	no	no	no	no
5	A	2000	10ms	0ms	21.1	Inter	Gated	5	Sum	1	2000	0	Butter	-35.15dB	04/06/95	13:38	no	no	no	no	no
6	A	2000	10ms	0ms	21.1	Inter	Gated	6	Sum	1	2000	0	Butter	-32.85dB	04/06/95	13:40	no	no	no	no	no

STIM	Trans	Type	Pol	Dur	Level	Freq	Pla	Ramp	Env	Noi	NLev	dB	Trans	Type	Pol	Dur	Level	Freq	Pla	Ramp	Env	Noi	NLev	dB
1	Phone	Click	Rar	100us	60					Off		nHL	Phone	Off								Off		nHL
2	Phone	Click	Rar	100us	30					Off		nHL	Phone	Off								Off		nHL
3	Phone	Click	Rar	100us	20					Off		nHL	Phone	Off								Off		nHL
4	Phone	Click	Rar	100us	10					Off		nHL	Phone	Off								Off		nHL
5	Phone	Click	Rar	100us	5					Off		nHL	Phone	Off								Off		nHL
6	Phone	Click	Rar	100us	0					Off		nHL	Phone	Off								Off		nHL

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Last:
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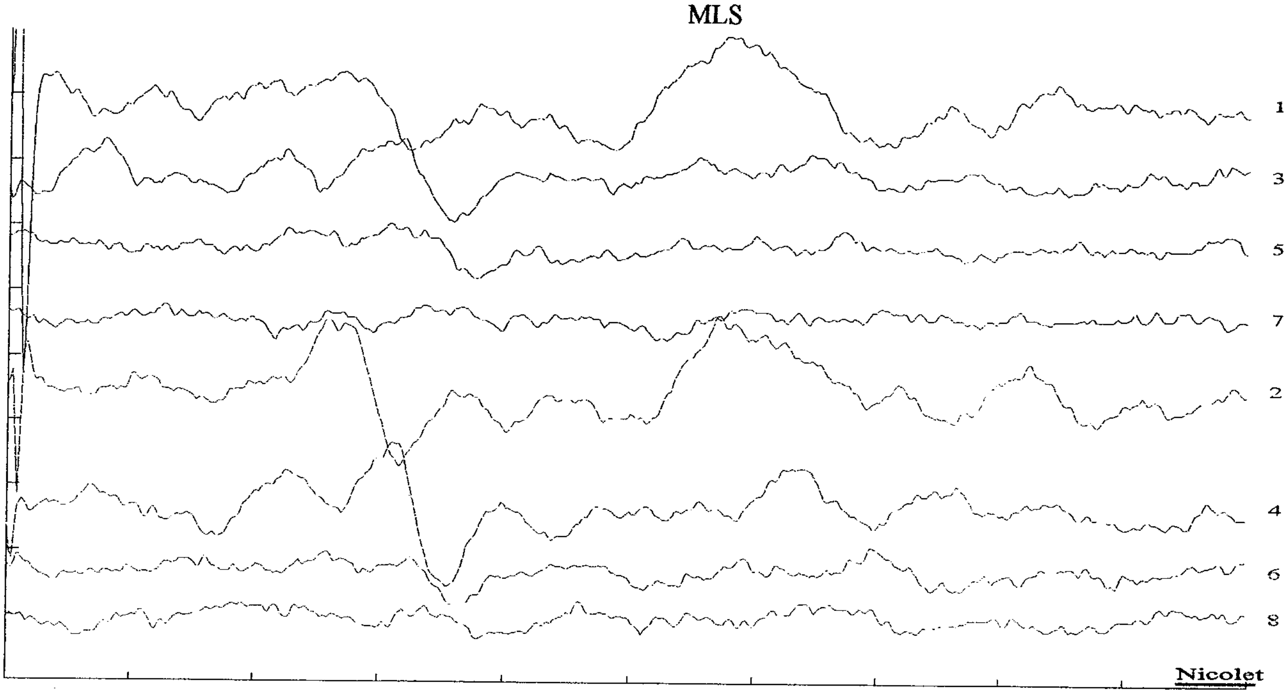
First:
Birthdate: 11/10/72
Examiner: skw

Gender: f

Case History:

Notes/Impressions:

MLS



Sensitivity and Sweep Time Per Division

1	0.12 uV	2.4 msec	2	0.12 uV	2.4 msec	3	0.12 uV	2.4 msec	4	0.12 uV	2.4 msec
5	0.12 uV	2.4 msec	6	0.12 uV	2.4 msec	7	0.12 uV	2.4 msec	8	0.12 uV	2.4 msec

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MLS

AMP	Elect	Mode	Sns	Lff	Hff	Notch	Artifact	REM	Remarks
1	Fz-A1	Run	20uV	150Hz	3K	Off	On	1	
2	Fz-A1	Run	20uV	150Hz	3K	Off	On	2	
3	Fz-A1	Run	20uV	150Hz	3K	Off	On	3	
4	Fz-A1	Run	20uV	150Hz	3K	Off	On	4	
5	Fz-A1	Run	20uV	150Hz	3K	Off	On	5	
6	Fz-A1	Run	20uV	150Hz	3K	Off	On	6	
7	Fz-A1	Run	20uV	150Hz	3K	Off	On	7	
8	Fz-A1	Run	20uV	150Hz	3K	Off	On	8	

ACQ	Comm	Sweep	Time	Delay	Rate	Trigger	Stim	MISC	Type	Ch#	Accept	Reject	Filter	Fsp/SNR	Date	Time	Add	Sub	Inv	Filter	Smooth
1	A	800	24ms	0ms	200.0	Inter	Gated	1	Sum	1	800	158	Butter	-100.00dB	04/06/95	13:57	no	no	no	no	no
2	A	800	24ms	0ms	200.0	Inter	Gated	2	Sum	2	800	158	Butter	-100.00dB	04/06/95	13:57	no	no	no	no	no
3	A	800	24ms	0ms	200.0	Inter	Gated	3	Sum	1	800	23	Butter	-100.00dB	04/06/95	14:00	no	no	no	no	no
4	A	800	24ms	0ms	200.0	Inter	Gated	4	Sum	2	800	23	Butter	-100.00dB	04/06/95	14:00	no	no	no	no	no
5	A	800	24ms	0ms	200.0	Inter	Gated	5	Sum	1	800	10	Butter	-100.00dB	04/06/95	14:02	no	no	no	no	no
6	A	800	24ms	0ms	200.0	Inter	Gated	6	Sum	2	800	10	Butter	-100.00dB	04/06/95	14:02	no	no	no	no	no
7	A	800	24ms	0ms	200.0	Inter	Gated	7	Sum	1	800	0	Butter	-100.00dB	04/06/95	14:04	no	no	no	no	no
8	A	800	24ms	0ms	200.0	Inter	Gated	8	Sum	2	800	0	Butter	-100.00dB	04/06/95	14:04	no	no	no	no	no

STIM	Trans	Enable	Level	Auto	Inc	Max	dB	Trans	Enable	Level	Auto	Inc	Max	dB
1	Phone	On	60	Off	5	80	nHL	Phone	On	60	Off	5	80	nHL
2	Phone	On	60	Off	5	80	nHL	Phone	On	60	Off	5	80	nHL
3	Phone	On	30	Off	5	80	nHL	Phone	On	30	Off	5	80	nHL
4	Phone	On	30	Off	5	80	nHL	Phone	On	30	Off	5	80	nHL
5	Phone	On	20	Off	5	80	nHL	Phone	On	20	Off	5	80	nHL
6	Phone	On	20	Off	5	80	nHL	Phone	On	20	Off	5	80	nHL
7	Phone	On	10	Off	5	80	nHL	Phone	On	10	Off	5	80	nHL
8	Phone	On	10	Off	5	80	nHL	Phone	On	10	Off	5	80	nHL

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Last:
Med ID: 09
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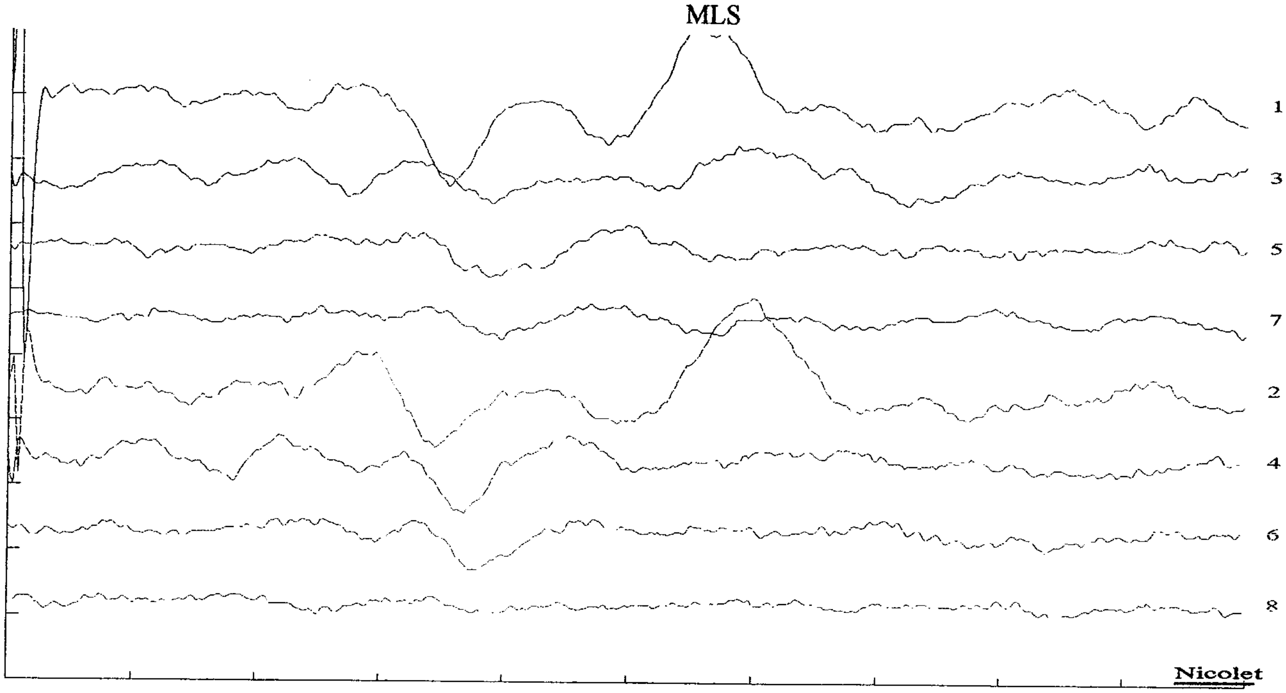
First:
Birthdate: 11/10/72
Examiner: skw

Gender: f

Case History:

Notes/Impressions:



Sensitivity and Sweep Time Per Division

1	0.12 uV	2.4 msec	2	0.12 uV	2.4 msec	3	0.12 uV	2.4 msec	4	0.12 uV	2.4 msec
5	0.12 uV	2.4 msec	6	0.12 uV	2.4 msec	7	0.12 uV	2.4 msec	8	0.12 uV	2.4 msec

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MLS

AMP	Elect	Mode	Sns	Lff	Hff	Notch	Artifact	REM	Remarks
1	Fz-A1	Run	20uV	150Hz	3K	Off	On	1	
2	Fz-A1	Run	20uV	150Hz	3K	Off	On	2	
3	Fz-A1	Run	20uV	150Hz	3K	Off	On	3	
4	Fz-A1	Run	20uV	150Hz	3K	Off	On	4	
5	Fz-A1	Run	20uV	150Hz	3K	Off	On	5	
6	Fz-A1	Run	20uV	150Hz	3K	Off	On	6	
7	Fz-A1	Run	20uV	150Hz	3K	Off	On	7	
8	Fz-A1	Run	20uV	150Hz	3K	Off	On	8	

ACQ	Comm	Sweep	Time	Delay	Rate	Trigger	Stim
1	A	800	24ms	0ms	400.0	Inter	Gated
2	A	800	24ms	0ms	400.0	Inter	Gated
3	A	800	24ms	0ms	400.0	Inter	Gated
4	A	800	24ms	0ms	400.0	Inter	Gated
5	A	800	24ms	0ms	400.0	Inter	Gated
6	A	800	24ms	0ms	400.0	Inter	Gated
7	A	800	24ms	0ms	400.0	Inter	Gated
8	A	800	24ms	0ms	400.0	Inter	Gated

MISC	Type	Ch#	Accept	Reject	Filter	Fsp/SNR	Date	Time	Add	Sub	Inv	Filter	Smooth
1	Sum	1	800	359	Butter	-100.00dB	04/06/95	14:08	no	no	no	no	no
2	Sum	2	800	359	Butter	-100.00dB	04/06/95	14:08	no	no	no	no	no
3	Sum	1	800	41	Butter	-100.00dB	04/06/95	14:11	no	no	no	no	no
4	Sum	2	800	41	Butter	-100.00dB	04/06/95	14:11	no	no	no	no	no
5	Sum	1	800	0	Butter	-100.00dB	04/06/95	14:14	no	no	no	no	no
6	Sum	2	800	0	Butter	-100.00dB	04/06/95	14:14	no	no	no	no	no
7	Sum	1	800	6	Butter	-100.00dB	04/06/95	14:16	no	no	no	no	no
8	Sum	2	800	6	Butter	-100.00dB	04/06/95	14:16	no	no	no	no	no

STIM	Trans	Enable	Level	Auto	Inc	Max	dB	Trans	Enable	Level	Auto	Inc	Max	dB
1	Phone	On	60	Off	5	80	nHL	Phone	On	60	Off	5	80	nHL
2	Phone	On	60	Off	5	80	nHL	Phone	On	60	Off	5	80	nHL
3	Phone	On	30	Off	5	80	nHL	Phone	On	30	Off	5	80	nHL
4	Phone	On	30	Off	5	80	nHL	Phone	On	30	Off	5	80	nHL
5	Phone	On	20	Off	5	80	nHL	Phone	On	20	Off	5	80	nHL
6	Phone	On	20	Off	5	80	nHL	Phone	On	20	Off	5	80	nHL
7	Phone	On	10	Off	5	80	nHL	Phone	On	10	Off	5	80	nHL
8	Phone	On	10	Off	5	80	nHL	Phone	On	10	Off	5	80	nHL

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Examiner: skw

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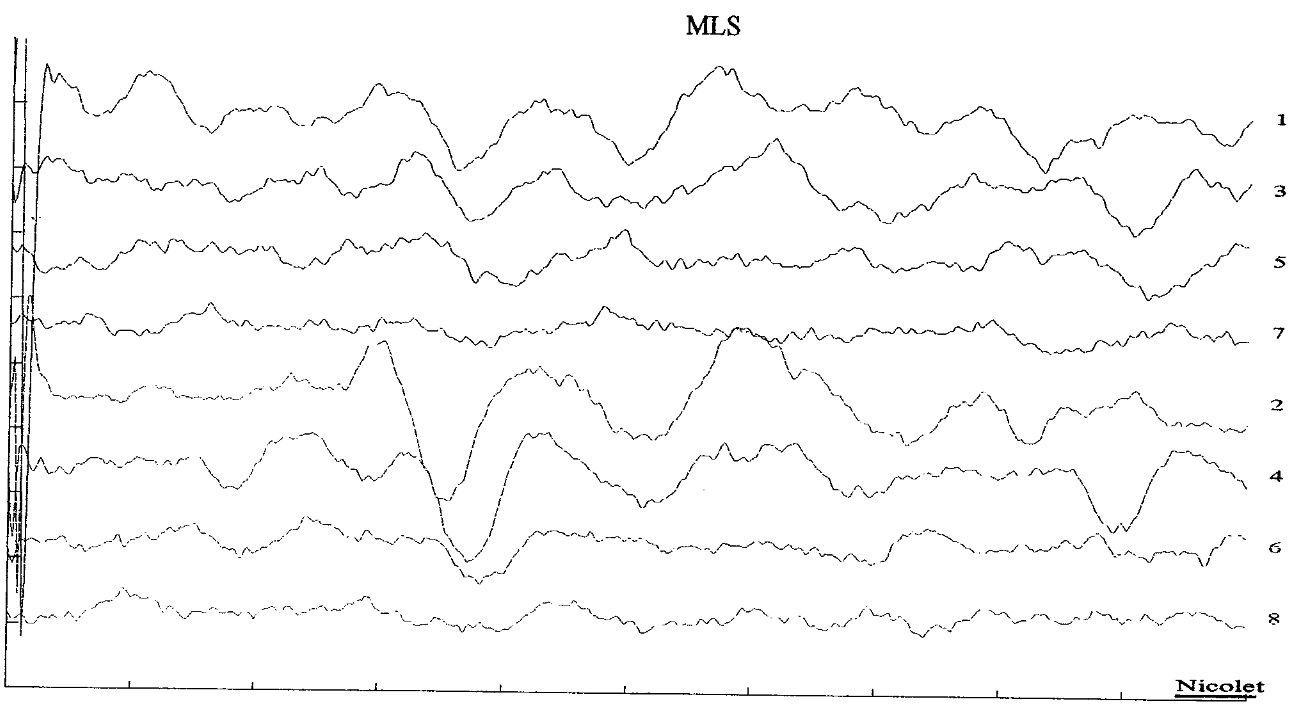
Case History:

Notes/Impressions:



Sensitivity and Sweep Time Per Division

1	0.06 uV	2.4 msec	2	0.06 uV	2.4 msec	3	0.06 uV	2.4 msec	4	0.06 uV	2.4 msec
5	0.06 uV	2.4 msec	6	0.06 uV	2.4 msec	7	0.06 uV	2.4 msec	8	0.06 uV	2.4 msec

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MLS

AMP	Elect	Mode	Sns	Lff	Hff	Notch	Artifact	REM	Remarks
1	Fz-A1	Run	20uV	150Hz	3K	Off	On	1	
2	Fz-A1	Run	20uV	150Hz	3K	Off	On	2	
3	Fz-A1	Run	20uV	150Hz	3K	Off	On	3	
4	Fz-A1	Run	20uV	150Hz	3K	Off	On	4	
5	Fz-A1	Run	20uV	150Hz	3K	Off	On	5	
6	Fz-A1	Run	20uV	150Hz	3K	Off	On	6	
7	Fz-A1	Run	20uV	150Hz	3K	Off	On	7	
8	Fz-A1	Run	20uV	150Hz	3K	Off	On	8	

ACQ	Comm	Sweep	Time	Delay	Rate	Trigger	Stim	MISC	Type	Ch#	Accept	Reject	Filter	Fsp/SNR	Date	Time	Add	Sub	Inv	Filter	Smooth
1	A	800	24ms	0ms	800.0	Inter	Gated	1	Sum	1	800	292	Butter	-100.00dB	04/06/95	14:20	no	no	no	no	no
2	A	800	24ms	0ms	800.0	Inter	Gated	2	Sum	2	800	292	Butter	-100.00dB	04/06/95	14:20	no	no	no	no	no
3	A	800	24ms	0ms	800.0	Inter	Gated	3	Sum	1	800	60	Butter	-100.00dB	04/06/95	14:24	no	no	no	no	no
4	A	800	24ms	0ms	800.0	Inter	Gated	4	Sum	2	800	60	Butter	-100.00dB	04/06/95	14:24	no	no	no	no	no
5	A	800	24ms	0ms	800.0	Inter	Gated	5	Sum	1	800	5	Butter	-100.00dB	04/06/95	14:26	no	no	no	no	no
6	A	800	24ms	0ms	800.0	Inter	Gated	6	Sum	2	800	5	Butter	-100.00dB	04/06/95	14:26	no	no	no	no	no
7	A	800	24ms	0ms	800.0	Inter	Gated	7	Sum	1	800	1	Butter	-100.00dB	04/06/95	14:29	no	no	no	no	no
8	A	800	24ms	0ms	800.0	Inter	Gated	8	Sum	2	800	1	Butter	-100.00dB	04/06/95	14:29	no	no	no	no	no

STIM	Trans	Enable	Level	Auto	Inc	Max	dB	Trans	Enable	Level	Auto	Inc	Max	dB
1	Phone	On	60	Off	5	80	nHL	Phone	On	60	Off	5	80	nHL
2	Phone	On	60	Off	5	80	nHL	Phone	On	60	Off	5	80	nHL
3	Phone	On	30	Off	5	80	nHL	Phone	On	30	Off	5	80	nHL
4	Phone	On	30	Off	5	80	nHL	Phone	On	30	Off	5	80	nHL
5	Phone	On	20	Off	5	80	nHL	Phone	On	20	Off	5	80	nHL
6	Phone	On	20	Off	5	80	nHL	Phone	On	20	Off	5	80	nHL
7	Phone	On	10	Off	5	80	nHL	Phone	On	10	Off	5	80	nHL
8	Phone	On	10	Off	5	80	nHL	Phone	On	10	Off	5	80	nHL

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